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REPORT

ON

WILSON RESERVOIR

RUSSELL COUNTY

KANSAS

EPA REGION VII

WORKING PAPER No. 525

WITH THE COOPERATION OF THE

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT

AND THE

KANSAS NATIONAL GUARD

April, 1977

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16 ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17 KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper Series.

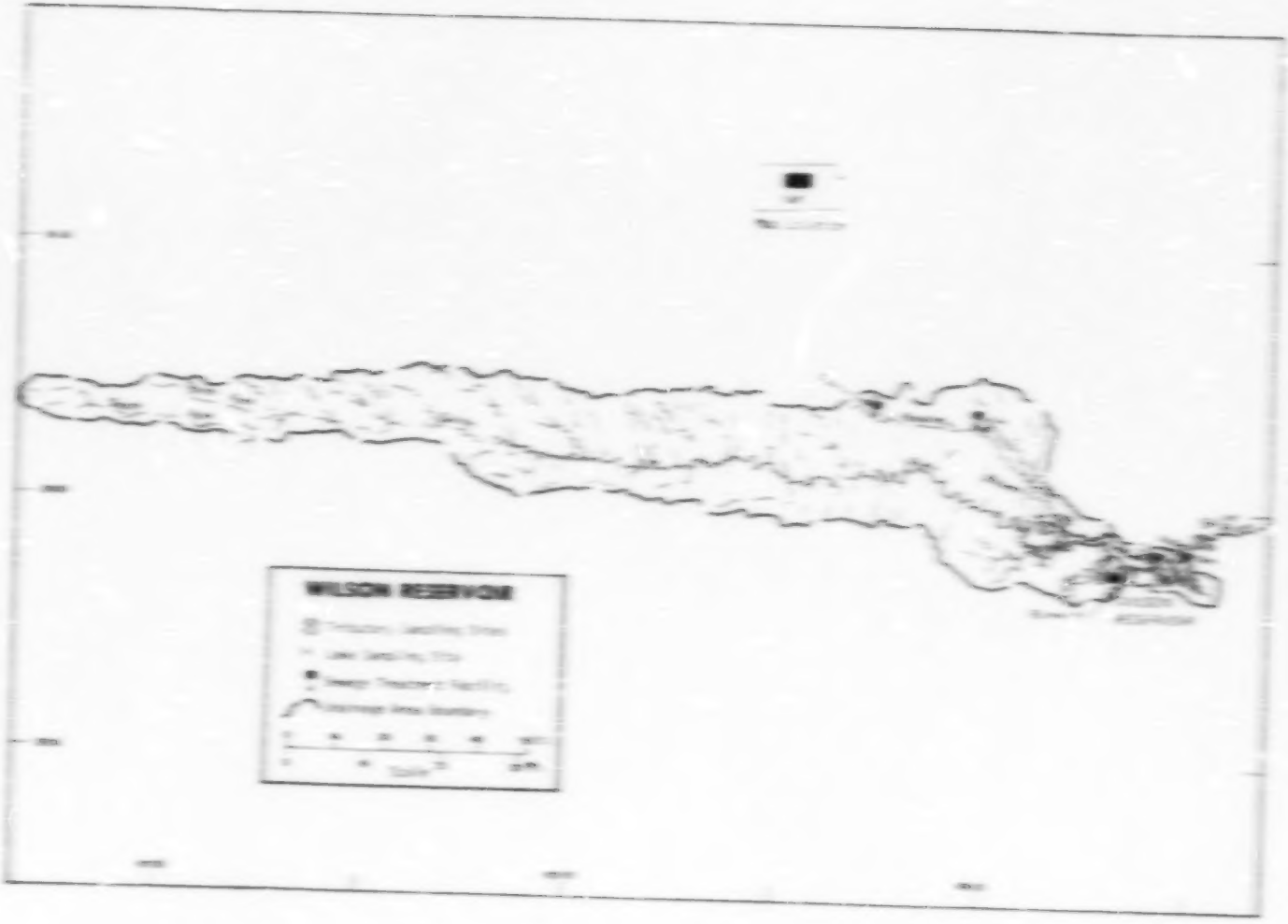
Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Allan L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Potta-watomie, Riley
Wilson	Russell


WILSON RESERVOIR

WILSON RESERVOIR

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I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Wilson Reservoir is mesotrophic. It ranked second in overall trophic quality among the 15 Kansas reservoirs sampled in 1974 when compared using a combination of six water quality parameters*. One of the reservoirs had less median total phosphorus, one had less and one had the same median dissolved orthophosphorus, two had less and one had the same median inorganic nitrogen, six had less mean chlorophyll a, and none of the other reservoirs had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at sampling stations 2 and 3 in June.

Survey limnologists did not observe macrophytes or surface concentrations of algae during sampling visits.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Wilson Reservoir was phosphorus limited at the time the sample was collected (04/12/74). The reservoir data indicate phosphorus limitation at all sampling stations and times.

* See Appendix A.

C. Nutrient Controllability:

1. Point Sources--During the sampling year, the listed point sources accounted for an estimated 22.1% of the total phosphorus input to Wilson Reservoir. The wastewater treatment plant at Plainville contributed 16.7%, the plant at Natoma contributed 3.9%, and the plant at Bunker Hill contributed 1.6% of the total.

The present phosphorus loading of 0.47 g/m^2/year is nearly 1.4 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). Continuation of this loading may increase primary productivity and eventually cause the reservoir to become eutrophic. Because the water-body is phosphorus limited, point-source phosphorus should be reduced to the greatest practicable extent to at least slow the present rate of enrichment.

2. Non-point sources--Non-point sources contributed 77.8% of the total phosphorus load during the sampling year. The Saline River contributed 62.7%, Cedar Creek contributed 0.7%, and Paradise Creek contributed 0.3%. The ungaged minor tributaries and immediate drainage contributed an estimated 10.4%.

The phosphorus export rates of the three tributaries were quite low (3 kg/km^2/yr and less; see page 12).

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry[††]:

1. Surface area: 36.42 kilometers^2.

2. Mean depth: 8.4 meters.

3. Maximum depth: =16.8 meters.

4. Volume: 305,900 x 10^6 m^3.

5. Mean hydraulic retention time: 2.8 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec.)*
Saline River	3,890.2	3.440
Cedar Creek	71.0	0.074
Paradise Creek	595.7	0.600
Minor tributaries & immediate drainage -	371.7	1.030
Totals	4,928.6	5.144

2. Outlet -

Saline River	4,965.0**	3.490

C. Precipitation***:

1. Year of sampling: 40.7 centimeters.

2. Mean annual: 68.0 centimeters.

† Table of metric conversions--Appendix B.
†† Kring, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Wilson Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 16.8 meters at station 1, 15.2 meters at station 2, and 12.2 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the June nutrient samples were not preserved properly and were not analyzed).

[illegible] OF [illegible] AND [illegible] CHARACTERISTICS FOR [illegible]
START JUNE 2003

PARAMETER	1ST SAMPLING : [illegible]			2ND SAMPLING : [illegible]			3RD SAMPLING (LAST) [illegible]		
	1 SITES			2 SITES			1 SITES		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEMP (C)	6.2 - 11.1	8.7	9.0	20.0 - 24.1	22.7	23.1	15.2 - 17.4	17.1	17.2
DISS OXY (MG/L)	9.0 - 10.2	10.0	10.1	7.8 - 9.2	8.1	8.0	7.8 - 8.1	8.0	8.0
CNDCTVY (MC-CM)	1[illegible] - 17[illegible]	16[illegible]	16[illegible]	21[illegible] - 22[illegible]	21[illegible]	22[illegible]	21[illegible] - 22[illegible]	[illegible]	22[illegible]
PH (STAND UNITS)	8.0 - 8.2	8.2	8.2	7.9 - 8.0	8.3	8.0	7.8 - 8.1	8.0	8.0
TOT ALK (MG/L)	15[illegible] - 16[illegible]	16[illegible]	16[illegible]	[illegible]	[illegible]	[illegible]	12[illegible] - 13[illegible]	13[illegible]	13[illegible]
TOT P (MG/L)	0.021 - 0.075	0.038	0.035	[illegible]	[illegible]	[illegible]	0.031 - 0.037	0.031	0.029
DISS P (MG/L)	0.03[illegible] - 0.037	0.03[illegible]	0.03[illegible]	[illegible]	[illegible]	[illegible]	0.032 - 0.03[illegible]	0.03[illegible]	0.03[illegible]
NO2+NO3 (MG/L)	0.38[illegible] - 1.23[illegible]	0.42[illegible]	0.42[illegible]	[illegible]	[illegible]	[illegible]	0.04[illegible] - 0.12[illegible]	0.12[illegible]	0.12[illegible]
AMMONIA (MG/L)	0.04[illegible] - 0.07[illegible]	0.05[illegible]	0.05[illegible]	[illegible]	[illegible]	[illegible]	0.02[illegible] - 0.04[illegible]	0.02[illegible]	0.02[illegible]
KJEL N (MG/L)	0.48[illegible] - 0.49[illegible]	0.49[illegible]	0.49[illegible]	[illegible]	[illegible]	[illegible]	0.33[illegible] - 0.48[illegible]	0.39[illegible]	0.40[illegible]
INORG N (MG/L)	0.35[illegible] - 1.27[illegible]	0.47[illegible]	0.47[illegible]	[illegible]	[illegible]	[illegible]	0.07[illegible] - 0.38[illegible]	0.17[illegible]	0.16[illegible]
TOTAL N (MG/L)	0.78[illegible] - 1.67[illegible]	1.27[illegible]	0.97[illegible]	[illegible]	[illegible]	[illegible]	0.34[illegible] - 1.02[illegible]	0.76[illegible]	0.72[illegible]
CHLOPHYL A (UG/L)	5.0 - 33.0	9.7	5.0	0.0 - 2.5	1.7	1.0	25.0 - 35[illegible]	27.0	27.0
SECCHI METERS	0.5 - 0.9	0.7	0.7	2.0 - 2.0	2.0	2.7	1.0 - 1.1	1.1	1.1

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/12/74	1. Synedra sp.	3,438
	2. Chroomonas sp.	1,413
	3. Stephanodiscus sp.	1,130
	4. Oocystis sp.	1,083
	5. Ankistrodesmus sp.	659
	Other genera	1,460
	Total	9,183
06/26/74	1. Chroomonas sp.	575
	2. Cryptomonas sp.	157
	3. Oocystis sp.	62
	4. Sphaerocystis sp.	52
	Total	836
10/01/74	1. Stephanodiscus sp.	1,847
	2. Oscillatoria sp.	1,203
	3. Synedra sp.	601
	4. Oocystis sp.	290
	5. Dactylococcopsis sp.	129
	Other genera	516
	Total	4,584

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
04/12/74	1	5.0
	2	6.0
	3	11.8
06/26/74	1	0.8
	2	2.5
	3	1.9
10/01/74	1	19.4
	2	16.9
	3	17.5

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.285	0.1
0.050 P	<0.005	0.285	6.5
0.050 P + 1.0 N	<0.005	1.285	14.1
1.0 N	<0.005	1.285	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Wilson Reservoir was low at the time the sample was collected (04/12/74). Also, the increase in yield with the addition of phosphorus alone indicates that the reservoir was phosphorus limited at that time. Note that the addition

of nitrogen alone resulted in a yield no greater than that of the control.

The reservoir data indicate phosphorus limitation as well. The mean inorganic nitrogen/orthophosphorus ratios were 30/1 or greater at all sampling stations and times, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the months of May, June, and July when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Cedar Creek at station B-1 and the mean annual ZZ flow.

The operator of the Plainville wastewater treatment plant provided monthly effluent samples, however, flows appear to be estimates. The operator of the Natoma wastewater treatment plant also provided monthly samples but flows were not available. Therefore, nutrient loads from these sources and those from the wastewater treatment plant

at Bunker Hill, which was not sampled, were estimated at 1.134 kg P and 3.401 kg N/capita/year; and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Plainville	2,518	tr. filter	953.1	Trib. of Paradise Creek
Natoma	590	tr. filter	223.3	Paradise Creek
Bunker Hill	240	stab. pond	90.8	Unnamed Trib./ Wilson Reservoir

2. Known industrial - None

* Treatment plant questionnaires; Anonymous, 1971.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Saline River	10,740	62.7
Cedar Creek	130	0.7
Paradise Creek	50	0.3
b. Minor tributaries & immediate drainage (non-point load) -	1,785	10.4
c. Known municipal STP's -		
Bunker Hill	270	1.6
Natoma	670	3.9
Plainville	2,855	16.7
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	635	3.7
Total	17,135	100.0

2. Outputs -

Lake outlet - Saline River 5,065

3. Net annual P accumulation - 12,070 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Saline River	134,305	46.3
Cedar Creek	4,950	1.7
Paradise Creek	31,190	10.7
b. Minor tributaries & immediate drainage (non-point load) -	68,895	23.7
c. Known municipal STP's -		
Bunker Hill	815	0.3
Natoma	2,005	0.7
Plainville	8,565	3.0
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	39,320	13.6
Total	290,045	100.0

2. Outputs -

Lake outlet - Saline River	160,140

3. Net annual N accumulation - 129,905 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Saline River	3	35
Cedar Creek	2	70
Paradise Creek	<1	62

* See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.47	0.33	8.0	3.6

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Wilson Reservoir:

"Dangerous" (eutrophic loading)	0.34
"Permissible" (oligotrophic loading)	0.17

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN CHLPHS A	SDD-MEAN SEC	MEAN CHLPHA	15-MIN TO	MEDIAN [illegible] P
2001	CEDAR BLUFF RESERVOIR	0.017	0.055	431.017	4.217	10.000	0.034
2002	COUNCIL GROVE	0.064	0.028	495.886	5.769	16.405	0.028
2003	ELK CITY	0.038	0.598	496.488	3.202	24.000	0.003
2004	FALL RIVER RESERVOIR	0.053	0.478	486.667	7.483	9.286	0.029
2005	JOHN REDMOND RESERVOIR	0.119	1.250	492.667	9.467	8.200	0.046
2006	KANOPOLIS RESERVOIR	0.056	0.048	497.000	26.033	18.200	0.001
2007	MARION RESERVOIR	0.052	0.436	483.667	12.400	9.000	0.033
2008	MELVERN RESERVOIR	0.034	0.265	498.111	38.400	24.400	0.007
2009	MILFORD RESERVOIR	0.079	0.728	486.333	18.883	12.000	0.036
2010	NORTON RESERVOIR	0.122	0.118	476.750	28.368	6.801	0.036
2011	PERRY RESERVOIR	0.055	0.078	478.571	5.614	13.400	0.017
2012	POMONA RESERVOIR	0.044	1.240	481.333	8.312	13.000	0.021
2013	TORONTO RESERVOIR	0.067	0.425	486.500	5.583	17.000	0.011
2014	TUTTLE CREEK RESERVOIR	0.102	0.078	478.667	11.279	13.600	0.067
2015	WILSON RESERVOIR	0.021	0.286	496.222	8.867	13.400	0.004

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	2001	[illegible]	536
2	2015	[illegible]	439
3	2007	[illegible]	357
4	2003	ELK CITY	350
5	2004	[illegible]	329
6	2019	[illegible]	325
7	2013	[illegible]	303
8	2018	[illegible]	292
9	2011	[illegible]	276
10	2006	[illegible]	271
11	2017	[illegible]	267
12	2012	[illegible]	238
13	2009	[illegible]	234
14	2005	[illegible]	164
15	2014	[illegible]	139

| | | |

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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[illegible]
[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	%	[illegible]	[illegible]		[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7,000	37,000	79,000	1,150	5,450		
[illegible]	[illegible]	[illegible]	28,000	5,400	1,200	4,800	7,400		
[illegible]			15,000	4,000	8,200	5,100	5,400		
[illegible]	[illegible]	[illegible]	15,000	10,500	8,600	2,200	5,700		
[illegible]	[illegible]	[illegible]	7,000	30,000	11,500	6,400	6,300		
[illegible]	[illegible]	[illegible]	15,000	15,500	6,300	1,150	4,400		
[illegible]	[illegible]	[illegible]	25,000	19,000	6,500	3,500	4,300		
[illegible]			15,000	6,700	8,100	1,130	2,700		
[illegible]	[illegible]	[illegible]	13,500	11,400	6,000	1,000	3,550		
[illegible]	[illegible]	[illegible]	7,500	15,500	1,200	1,400	4,000		
[illegible]			15,000	10,500	2,400	4,200	5,075		
[illegible]	[illegible]	[illegible]	2,200	35,500	17,000	1,050	6,350		
[illegible]			25,000	12,000	2,700	3,100	4,000		

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* VALUE KNOWN TO BE
LESS THAN [illegible] INDICATED